

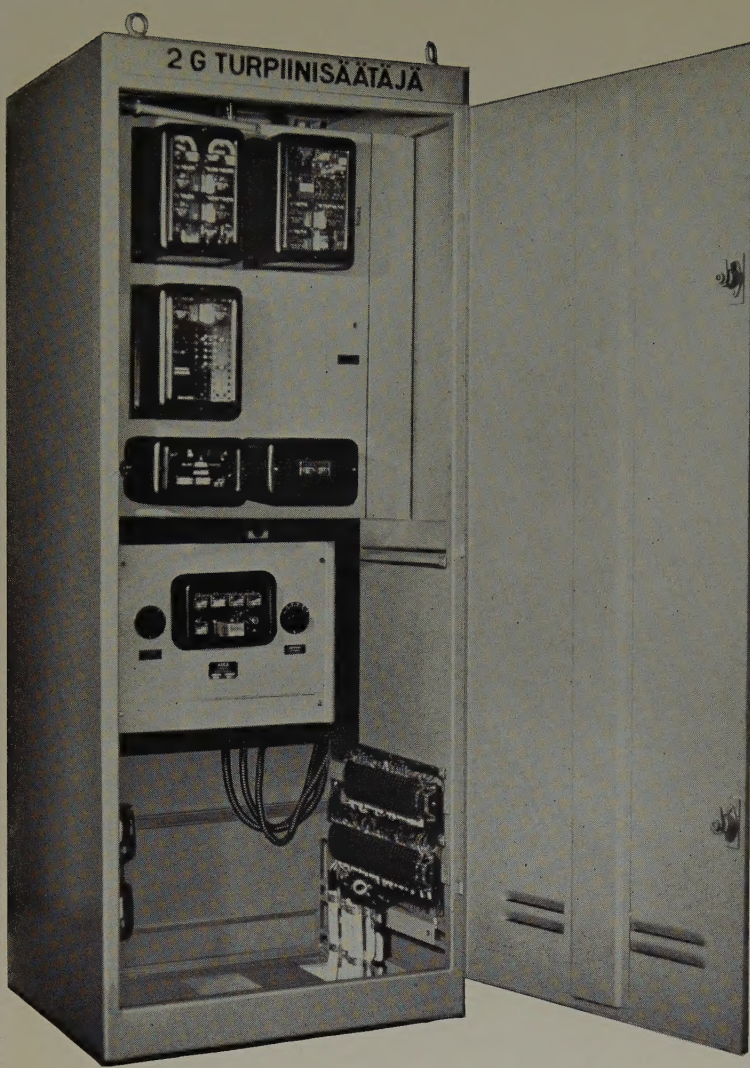


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*The machine hall at Stor-
norrfors Power-station with
the three Asea generators,
each rated at 150 MVA.
(F 535. Photo Ekholtz)*



Cubicle for an ASEA electro-hydraulic governor for 55,000 h.p. Kaplan turbine. (54279)

ELECTRO-HYDRAULIC GOVERNORS

are controlling today
8.5 million horse power

Since the first ASEA governor of commercial design went into operation in 1944, ASEA has delivered or has now on order, governors for a total turbine output of more than

11,000,000 h.p.

Among these are also governors for steam and gas turbines.

Reference List

Country	Number of governors	Turbine output h.p.
Australia	6	385,000
Austria	6	263,000
Brazil	4	800,000
Canada	9	380,000
China	1	11,000
Finland	15	660,000
France	4	240,000
India	1	57,000
Japan	17	1,230,000
Norway	9	560,000
Sovjet Union	5	96,000
Spain	2	37,000
Sweden	100	6,320,000
Venezuela	2	27,000
Yugoslavia	2	72,000
Total in April 1960	183	11,138,000

To the right

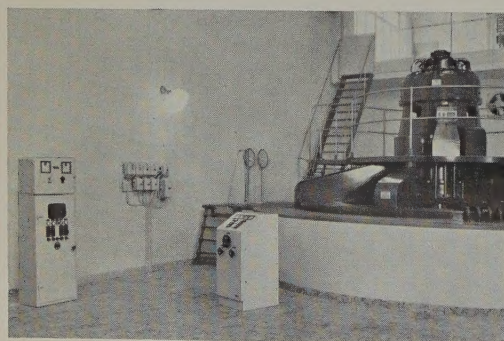
Interior view of the Swedish power-station Stornorrfor with three 150,000 kVA ASEA generators. The turbines are equipped with ASEA electro-hydraulic governors. (53865)

To the left

Complete electro-hydraulic governor delivered by ASEA in 1948. (39965)



ASEA



THE NEW ASEA HIGH-CURRENT LABORATORY AT LUDVIKA

Jörgen Zinck-Petersen, *High-power Laboratory, Ludvika*

U.D.C. 621.317.2:621.3.027.7
Asea Reg. 79

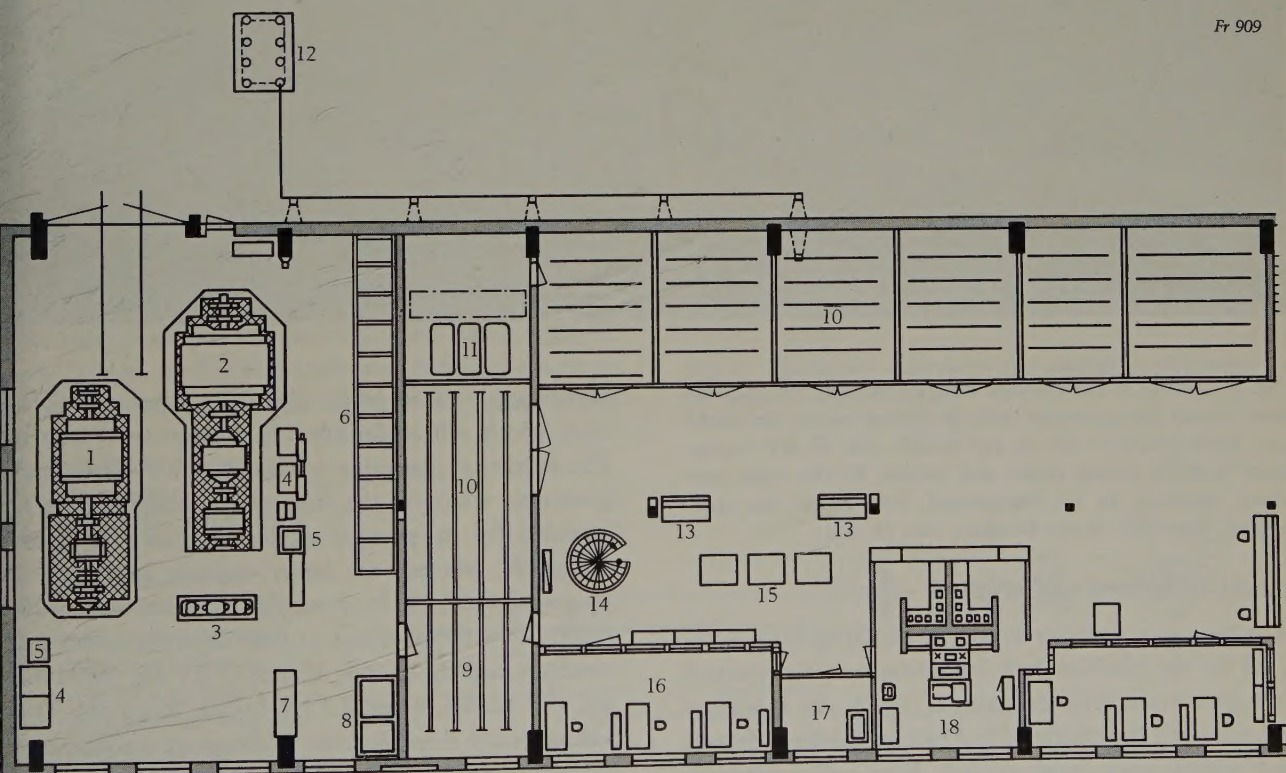
The High-current Laboratory at Ludvika has moved into new premises and forms a section within the High-power Laboratory. It now has at its disposal more space and more practical equipment, which includes new short-circuit test generators, one of which has a static exciter with automatic regulation of the generator voltage or current.

The old combined High-voltage and High-power Laboratory, which was inaugurated in 1933, included a high-current transformer with a total short-circuit power of 375 MVA. The site of this transformer was called the High-current Section. Here, tests were performed at high currents, utilising as source of supply the short-

circuit test generator of 1,000 MVA, which had been installed at that time. The testing capacity of this section was increased considerably at the beginning of the 1940's, when it became possible both to supply the transformer from three 20 MVA short-circuit generators, and to perform certain tests direct with the machines, without having recourse to the transformer. When the new High-power Laboratory was inaugurated in separate premises in 1958, it was found desirable also to move the High-current Laboratory. This laboratory is now located in the large assembly hall of the main building of the High-power Laboratory [cf. the Asea Journal 33 (1960):9, pp. 131-141].

Fig. 1. Plan of the High-current Laboratory. (Fr 909)

Fr 909



1. 60 MVA generator with its driving motor
2. 20 MVA generator with its driving motor and exciter
3. Auxiliary motor-generator set
4. Starting resistor
5. Cubicle for field circuit-breakers
6. Cubicles for static exciter, generator-

- winding change-over switches, back-up circuit-breakers and high-speed making switches
7. Control board
8. Cubicles for incoming supply
9. Workshop and test cell
10. Test cells
11. High-current transformer

12. Transformer, 100 kV
13. Control desks
14. Spiral staircase to reactor and resistor rooms
15. Oscillographs
16. Office
17. Cloak-room and wash room
18. Dark room

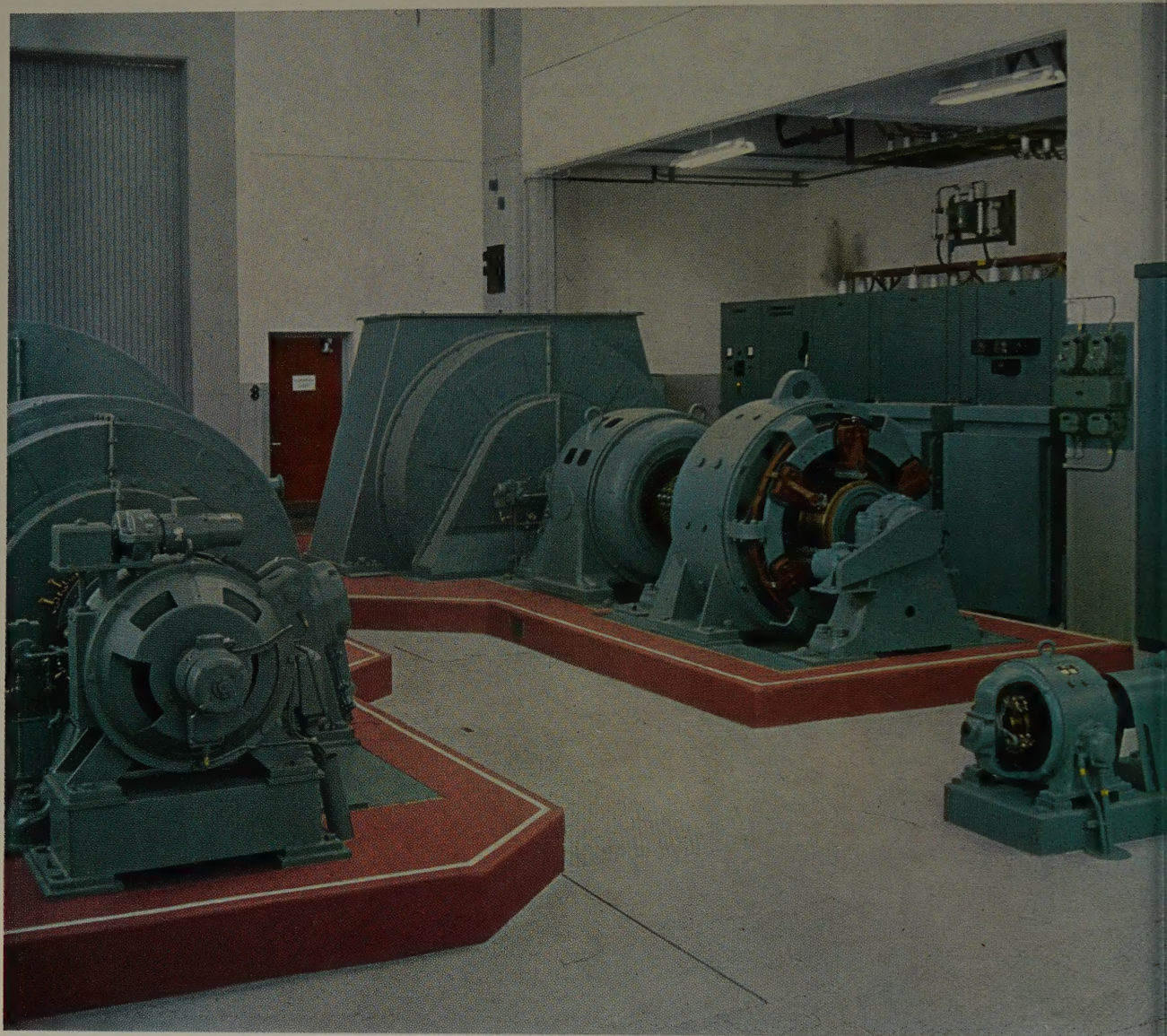


Fig. 2. Interior of the machine hall. To the left, the 60 MVA short-circuit test generator with its driving motor and auxiliary motor-generator set. In the middle, the 20 MVA generator with its driving motor and exciter. To the right, auxiliary machines. In the background, cubicles for the static exciter, generator circuit-breakers, etc. (F 443)

HIGH-CURRENT EQUIPMENT

The floor area available of 900 m² (9,700 sq.ft.) is occupied by the machine hall containing two short-circuit test generators, nine test cells, of which one is utilised for Schlieren investigations and two for mechanical tests, the control room with control desks, offices for the laboratory personnel, a dark room, and, on galleries, the resistor and reactor rooms. A plan of the ground floor of the laboratory is shown in Fig. 1.

The three-phase generators are driven by asynchronous motors. One of the sets has a short-circuit power of 20 MVA (for 0.2 s) and is excited from a directly connected d.c. generator. The other set, which has a short-

circuit power of 60 MVA (for 0.2 s), has a static exciter, which will be described in greater detail later on. The maximum generator voltage is 12 kV. The smaller generator, which at the time of its designing was not intended for its present application, has two circuits per phase, whereas the larger machine has three. By means of isolators, it is possible to take out the full power from the machines at four different voltages per machine, namely 12, 6.9, 6 and 3.5 kV for the smaller set, and 12, 6.9, 4 and 2.3 kV for the larger set. These values clearly show that for a laboratory machine three circuits per phase present considerable advantages. On the one hand, it is possible to take out the full power at a lower voltage, and, on the other hand, a more uniform voltage range is obtained. The interior of the machine hall is shown in Fig. 2.

Two 10 kV busbar systems – one from each machine – connect the tap changers to the generator circuit-breakers and high-speed making switches. The generator circuit-

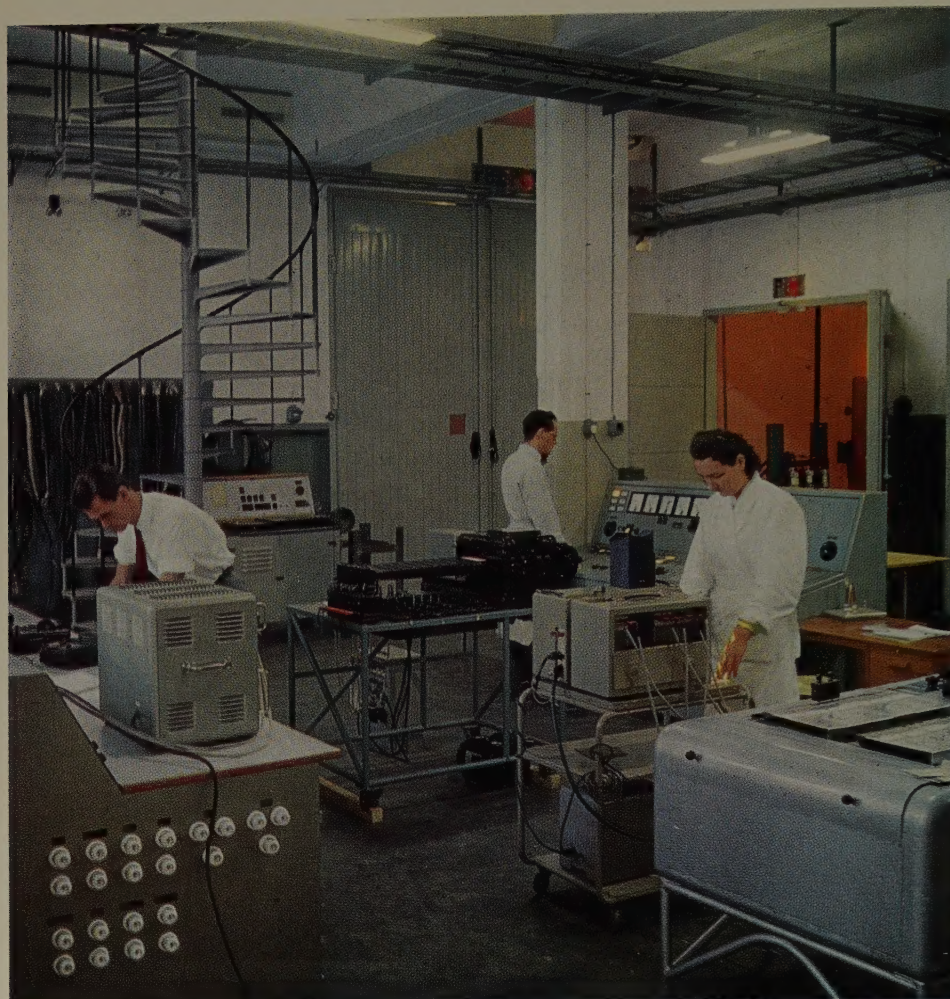


Fig. 5. The control room. In the foreground, electro-magnetic oscillographs, in the middle, the control desk for the 20 MVA set, in the background, two of the test cells. (F 444)

When the two machines of the High-current Laboratory are run in parallel, peak currents of up to about 300 kA can be obtained with a fully asymmetrical wave. If the high-power generator of 1,000 MVA is connected up behind (a special cable link is available between this and the high-current transformer bank), it is possible to take out peak currents of 500–600 kA.

An outdoor single-phase transformer, rated at 3.6 MVA (continuous power) with a short-circuit power of 60 MVA, a primary voltage of 7 kV, and a secondary voltage reconnectable between 100, 50 and 25 kV, is provided for performing tests at voltages above 12 kV. The primary side can be connected with the aid of a two-way isolator to either of the generators, whereas the secondary side is permanently connected to two test cells, of which one is intended for Schlieren investigations.

The large outdoor capacitor bank of the High-power Laboratory can be utilised for performing breaking tests with a capacitive load. This bank, which is connected to one of the test cells via a 10 kV cable, comprises 864 capacitor units rated at 25 kVAr, 1 kV, 50 c/s. Isolators are used for making the necessary reconnections in the bank.

Static exciter

As already mentioned above, the 60 MVA generator is excited from a rectifier. This is a by no means exceptional method of excitation, nor is the fact that a mercury-arc rectifier is provided with automatic regulation of the current or voltage output. On the other hand, it is more unusual for a short-circuit test generator to be provided with such rapid means of regulation direct on the alternating current and voltage output during the period of the short circuit as is the case with the largest generator of the High-current Laboratory. The use of this automatic regulating equipment provides a very good solution to the complicated problem of maintaining a constant short-circuit power over extended periods.

As is well known, a short circuit on a generator leads to the rapid damping of the main flux of the machine. During the initial periods, the original flux is retained to a certain extent due to the effect of damping windings, eddy currents in the pole shoes and the like and, later on, by the field winding, which strives to maintain its original flux constant. A reduction in this flux is, however, inevitable due to the losses in the field circuit, unless steps are taken to counteract this reduction by increasing simultaneously the field current to such a

Fig. 6. The control desk for the 60 MVA set. The generator no-load voltage is being set prior to a short-circuit test. The two handwheels to the left are used for setting the automatically regulated current and voltage level. (F 445)



value that the original air-gap flux is maintained constant.

In practice, this can be achieved in a number of different ways. Occasionally, use is made of flying excitation, where the short circuit is initiated while the generator field is still rising. Another method, which is really a modification of the previous one, consists in the short-circuiting of a resistor in the field circuit in conjunction with, or just before, the short circuit in the main generator circuit. The application of both these methods requires powerful exciters, careful calculations, knowledge of the electrical data of the test circuit used and, generally, a number of "trial shots". These drawbacks become less pronounced, nevertheless, as the laboratory personnel obtains greater experience.

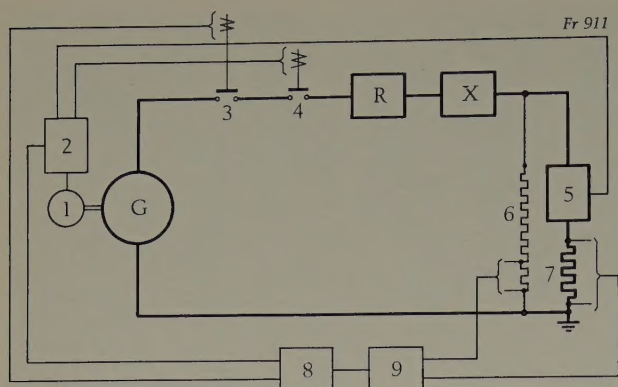
When performing tests at a constant current with the generator provided with the static exciter, the operating procedure is extremely simple. The generator voltage is set with a handwheel to a value which yields a current corresponding approximately to the desired value when the short circuit is initiated in the main circuit. After this, the desired current is set on another handwheel. When the short circuit has been initiated, the set short-circuit current is obtained for a period which

is limited only by the thermal strength of the laboratory equipment. When the short circuit is interrupted, the generator voltage returns to the no-load value set in advance. Oscillographic recordings of a short-circuit test with and without automatic regulation are reproduced in Fig. 3.

The control equipment comprises two units, which can be connected up alternately with a rotary switch on the control desk. These two units are

- a) a grid-control unit for automatic regulation of the alternating current and voltage of the short-circuit test generator
- b) a grid-control unit with three predetermined control positions which can be connected up by means of contacts in the sequence controller.

The grid-control unit (a) is a modified standard Asea control unit for mercury-arc rectifiers and operates with transducers in both the amplifier and the phase shifter. Regulation takes place with a constant voltage or current output from the short-circuit test generator. An elementary diagram illustrating this system is shown in Fig. 4.



G. Generator R. Resistor set X. Reactor set

1. Pilot generator
2. Synchronising device for high-speed making switch and test object
3. Back-up circuit-breaker
4. High-speed making switch
5. Test object
6. Voltage divider
7. Low-ohmic shunt
8. Sequence controller
9. Oscillograph

Fig. 7. Elementary diagram for test circuit with control and measuring circuits. (Fr 911)

The generator voltage is sensed with a voltage transformer 4, the secondary voltage of which is rectified 6, smoothed and fed to a control winding in a transducer amplifier 8. The reference value is obtained from a constant-current-fed potentiometer 10, which feeds another control winding in the amplifier. The difference between the magnetomotive forces of the two windings results in a certain output from the amplifier, which, via an intermediate amplifier 11, actuates a phase shifter 12. This in its turn feeds voltage with the necessary phase angle to the grid of the rectifier 14.

The generator current is sensed with three current transformers 3, which are connected up in such a way that they measure the phase current of the generator irrespective of its connection. The secondary sides of the current transformers are connected via intermediate transformers, a semi-conductor rectifier 5 and a filter to a control winding in another transducer amplifier 7. The desired current level is obtained in the same way as for the voltage. The two amplifier transducers are connected relative to one another in such a way that voltage regulation is obtained as long as the current remains below the set value. When the current has reached this value, the equipment changes over to current regulation. The speed of response is shown in the oscillograms reproduced in Fig. 3.

The grid-control unit (b) for the three predetermined control positions comprises three transformers with double windings on both the primary and the secondary sides. The transformers are polygon-connected with

their primary sides fed with the generator voltage. The secondary sides feed three sets of potentiometers mounted in the control desk and are operated with handwheels on this.

The control voltage can be displaced up to 120 electrical degrees by making the necessary settings on the potentiometer handwheels. Three individual control positions with a constant and predetermined control angle, and consequently three different excitation levels, may be obtained via relays controlled from the sequence controller. With properly selected settings, it is possible to achieve a slightly greater speed of response than with the automatically regulated system.

The rectifier is designed for 300 A with a continuous load and 1,200 A for 2 s. Service experience with the static exciter has been extremely satisfactory.

ACTIVITIES OF THE LABORATORY

The main purpose of the laboratory is to assist the design departments by means of practical tests for the purpose of developing the best possible designs. The work entrusted to the laboratory is divided up among the laboratory engineers, who with the assistance of the erection personnel are responsible for connecting up the test object and then carrying out the test itself. The machines are started from a control board in the machine hall. The test itself is supervised from control desks, one for each machine, in the control room from where a good view of the test cell housing the test object is obtained. The interior of the control room is shown in Fig. 5. Control signals for starting and stopping of the oscillographs, the operation of the high-speed making switches, the back-up circuit-breakers, etc., all these corresponding to the programme determined in advance, are transmitted from a sequence controller. The control desk for the 60 MVA set is shown in Fig. 6, and an elementary diagram of a typical test circuit is illustrated in Fig. 7.

The majority of the tests performed in the laboratory can be related to one or several of the following categories: impulse tests, short-time current tests, temperature-rise tests, breaking tests, special tests on fuses.

Impulse and short-time current tests are often performed simultaneously (asymmetrical connection). The tests are carried out on all types of switchgear equipment, such as isolators, distribution transformers, current transformers, circuit-breakers, busbars, for the purpose of checking both whether the material can withstand the dynamic effects of the current forces and whether the different components from the thermal viewpoint are properly dimensioned for short-circuit currents of a given size for a given time.

temperature-rise tests are intended to determine the steady-state temperature at currents within the rated current range. The tests are performed on the above-mentioned types of equipment as well as on fuses, components for rectifiers, bushings, etc.

breaking tests cover both acceptance and experimental tests. The test objects comprise diverter switches, tap changers, load switches as well as all types of circuit-breaker included in distribution networks for voltages up to 12 kV. The laboratory is particularly suited for investigating the ability of circuit-breakers to interrupt small inductive currents, and for performing capacitive breaking tests.

use tests are performed on all types of fuse for rated voltages between 250 V and 12 kV. These tests are carried out in order to determine, for example, the time/current characteristics of the fuses, their breaking

capacity at varying power factor, their nominal watts loss and their watts loss during the period of operation ($\int i^2 dt$). The max. short-circuit currents which can be attained in the laboratory depend on the test voltage used. At 550 – 575 V, fuses can be tested with a short-circuit current of 75 kA, R.M.S. value.

In addition to the above-mentioned tests, the laboratory is also responsible for research work, both under own management and in the form of assistance to other sections or departments within, and outside, the High-power Laboratory.

Service experience with the new High-current Laboratory has been very satisfactory. The equipment has proved to be well designed and easy to manage, which has resulted in an increased testing capacity. For tests at lower powers, the High-current Laboratory with its relatively low running costs constitutes a valuable complement to the High-power Laboratory.

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THE SWITCHGEAR AT STORNORRFORS POWER-STATION

Sven Svidén and Gunnar Nordlöf, Swedish State Power Board, Stockholm

U.D.C. 621.316.312
Asea Reg. 7244

The main 400 kV, 40 kV and 18 kV switchgear and the 10 kV and 380 V switchgear at Stornorrfor power-station are described. The most characteristic features are the new design of the 18 kV switchgear and the simplified 400 kV switchgear. The use of plastic-insulated low-voltage cable without lead sheathing is also of particular interest.

GENERAL REMARKS ON THE STATION

A general description of the Stornorrfor power-station has been provided in an earlier article by Mr G. von Geijer in the Asea Journal [3], in which the switchgear and other equipment are briefly described. The present article gives a more detailed account of the switchgear and, in addition, mentions some technical details concerning the provision of auxiliary power.

Stornorrfor power-station has main switchgear for voltages of 400 kV, 40 kV and 18 kV, as well as auxiliary switchgear for 10 kV and 380 V. The station is in a unique position among Swedish power-stations by virtue of its size, and it is not only the combined output which is greater than in any previous Swedish power-station, but also the output per generator set. The station installations are also widely scattered and this fact has been of decisive importance especially for the designing of the auxiliary power system. Certain other special circumstances also apply, and these, together with the size of the station, have exerted an influence on the designing of the main switchgear.

Naturally, the method selected for feeding the output of the station to the grid was an important factor in the designing of the main switchgear. The greater part of the output is fed out at 400 kV direct to the supergrid. There is no transformation at the station between various systems, for example, the 130 kV and 400 kV systems, and it is only its own output which is stepped up to 400 kV. The station has only one 400 kV line, which runs to the Ångerman River region via Harrsele power-station. The fact that Harrsele is connected to the 400 kV line means that the section of 400 kV line nearest to Stornorrfor is short (about 19 miles), and this fact too has influenced on the design of the switchgear.

However, Stornorrfor also feeds out a considerable amount of power at a lower voltage, that is, 40 kV. This is largely due to the proximity of the town of Umeå, which, in addition, owns a certain share in the

power produced at Stornorrfor. When drawing up the designs it also had to be borne in mind that the local 40 kV network may, in the future, be converted either completely, or in part, to 130 kV.

CERTAIN TECHNICAL REQUIREMENTS

Stornorrfor power-station works on a large network with many power-stations connected to it. It is therefore possible to permit brief interruptions in power production for changing over from one type of service to another, thus implying a certain simplification of the equipment in the station. For this reason, it was not thought necessary to be able to connect up the spare transformer for the transformation from generator voltage to 400 kV under load and without a break. Further, it was allowed that a fault in an auxiliary transformer will cause generator sets to be tripped out.

Another factor which has been utilised with the object of simplifying and reducing the cost of the switchgear is the use of telecommunication equipment for the transmission of protective relay impulses.

At Stornorrfor, very great demands are made upon the switchgear for the generator voltage as far as short-circuit currents and load currents are concerned. Because of the possibilities which arose as a result of the development of new insulation materials the time was ripe for redesigning the type of generator switchgear previously used, which had bare bars on porcelain post insulators.

The more recent developments in the field of materials also proved advantageous in yet another field in that plastic insulating material was used in the low-voltage cables.

CIRCUIT DIAGRAM

Because of the above, and other, circumstances, the circuit diagram of the station was drawn up as shown in Figs. 1 and 2.

The four generator sets of the station, each rated at 150 MVA, of which the fourth will however be installed at a later stage, have been divided up over two separate busbar systems, thus limiting the short-circuit power and the load current to reasonable values. For transforming the generator voltage from 18 kV to 400 kV, a transformer bank consisting of three 200 MVA single-phase units with the ratio of $18/\sqrt{3}$ kV has been selected with a

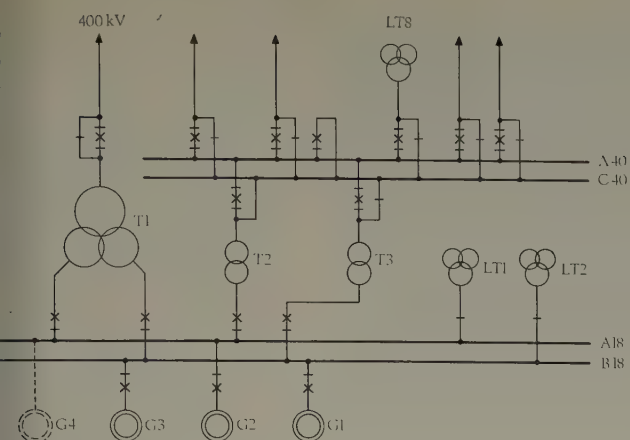


Fig. 1. Single-line diagram. (Fr 843)

fourth unit as a stand-by (Fig. 2). Since the generators are divided up into two systems, the transformers have been designed with two separate 18 kV windings. The reactance between these limits the transmission of short-circuit power from one 18 kV system to the other. Each 18 kV transformer winding has been provided with a two-pole circuit-breaker, thus taking advantage of the possibilities which this arrangement of the circuit-breakers offers as far as lower load current and lower demands on breaking capacity are concerned.

On the 400 kV side, isolator switchgear for connecting up the stand-by units, and a three-pole circuit-breaker between the transformer bank and the 400 kV line have been installed. There is no spare circuit-breaker on the 400 kV side, but only a by-pass isolator. When the circuit-breaker is by-passed, the line breaker at the other end of the line (that is to say, at Harrsele) acts as the transformer circuit-breaker.

The 40 kV switchgear has a normal circuit diagram, including a main busbar and an auxiliary busbar with a spare circuit-breaker. It is fed from the 18 kV system via two 60 MVA three-phase transformers with the ratio of 18/45 kV (T2 and T3 in Fig. 1).

THE 18 kV SWITCHGEAR

Reasons for the new design

The generator switchgear at Stornorrfor was to be designed for a greater load current and a greater short-circuit power than in any previous State Power Board station. The high load current (6,000 A) required a cross-sectional area of 4,500 mm² (6.98 sq.in.), which meant that the busbar itself had the strength to withstand heavy short-circuit forces. A consequence of this was that the busbar allowed such a large distance between insulators that it proved to be difficult to obtain porcelain insulators which would withstand these forces. From the mechanical point of view, it would be an ad-

vantage to reduce the bending stresses on the insulators, and, if possible, to find an insulating material stronger than porcelain.

Mechanical design

The total cross-sectional area of 4,500 mm² (6.98 sq.in.) per phase is divided up over six parallel copper bars 75×10 mm (2.95×0.39 in.), see Fig. 3. The bars are kept in place in relation to each other with the aid of spacers, which are set out at intervals of about 500 mm (20 in.). The phase gap between the bars is 900 mm (35 in.). The object of this large phase gap is primarily to prevent a single-phase earth fault from developing into a short circuit between the phases. Full-scale tests have, in fact, shown that an arc with a moderate current strength between one phase and earth at the voltage in question (18 kV) does not have time to develop into a short circuit between the phases before the earth fault protection has tripped, if the phase gap is as large as 900 mm (35 in.). In addition, this distance fits in well with the phase gap of the circuit-breakers and isolators.

The switchgear has been mechanically designed for a short-circuit power of about 5,000 MVA, which means a short-circuit force between the bars of 3,500 kg/m. As far as the busbars are concerned, a maximum insulator spacing of 2 m (6.6 ft) can be permitted. Since the weight of the busbars per phase is only 40 kg/m the greatest mechanical stresses will be caused by the forces between the conductors during short-circuiting. By placing the insulators in pairs between the busbars, as shown in Fig. 3 for a two-pole design, the result is that the heavy short-circuit forces occur in the bundle of bars itself and place a load on the insulators along their longitudinal axis and do not transfer the load to the foundation. Here, for the first time, instead of porcelain insulators, use was made of insulators of Araldite with a

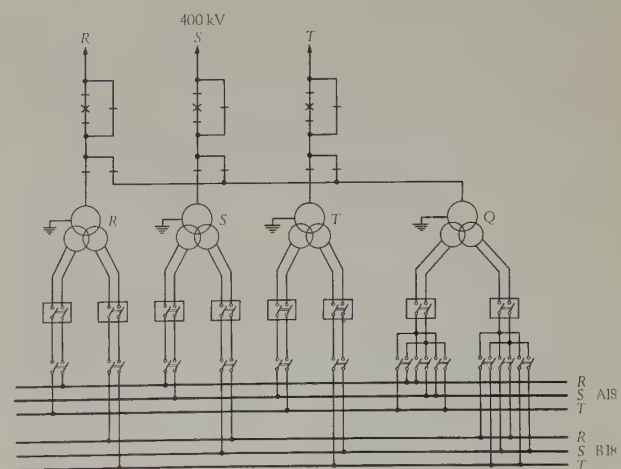
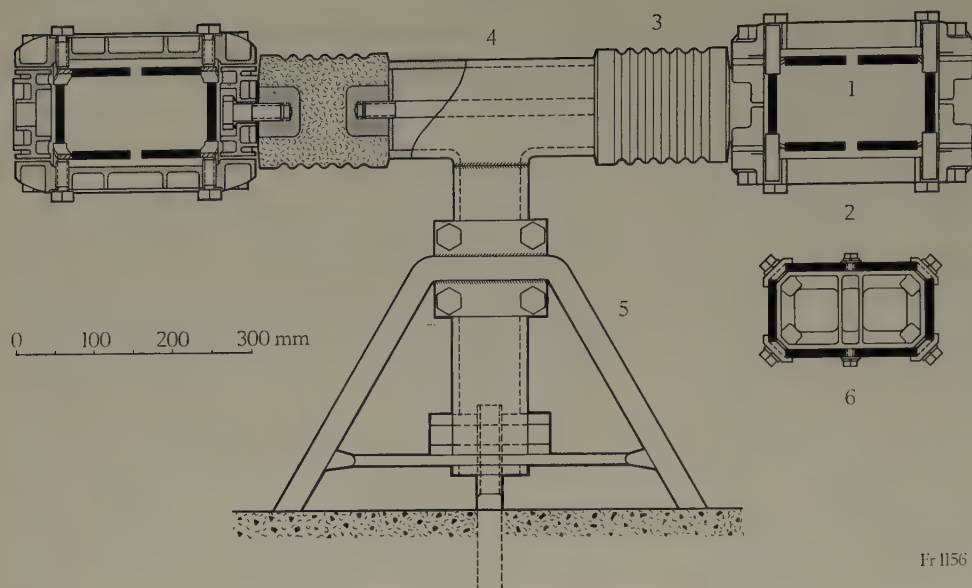


Fig. 2. Circuit diagram for the transformation from 18 kV to 400 kV. (Fr 844)



- 1 Phase busbar in box section ($6 \times 750 \text{ mm}^2$ per phase)
- 2 Busbar clamp
- 3 Araldite insulator
- 4 T-tube
- 5 Support
- 6 Vertical section through the phase busbar with spacer

Fig. 3. Vertical section through the 18 kV busbar assembly with the insulator bridge.

Fr 1156

quartz filler. Araldite is a thermo-setting resin with high mechanical strength. The tensile strength is $600 - 800 \text{ kg/cm}^2$ and the compression strength is $1,100 - 1,300 \text{ kg/cm}^2$. For porcelain, the corresponding figures are $300 - 500 \text{ kg/cm}^2$ and $4,500 - 5,500 \text{ kg/cm}^2$. For the araldite insulators used, a tensile force of $7,000 \text{ kg}$ per insulator and a bending force of $2,000 \text{ kg}$ per insulator are permitted. The busbars are fastened to the foundation by means of a support mounted between the latter and the central portion of the insulators at every other, or every third, insulator group (Fig. 4). This is sufficient to prevent sagging. Expansion joints are inserted at intervals of approximately 10 m (33 ft).

Alongside the purely mechanical advantages, this new design also has favourable properties in respect of heat dissipation, which has been improved still further by painting the busbars with a special red paint tested by Asea, the Royal Institute of Technology, and others. This red paint is considerably better than the bronze paint which was often used previously.

The bushings for walls and floors have also been made of Araldite and consist of corrugated plates with an external diameter of 800 mm (Fig. 5) with a central hole for the conductor. The plates will withstand greater radial mechanical stresses than normal porcelain bushings. The design saves space, and, further, the risk of electrical faults in these plates should be less than in porcelain bushings.

Because of the high loads in the bars, no closed circuits of magnetic material are permitted around the individual phases. This must be borne in mind when designing the steelwork since, otherwise, there would be the risk of the steels becoming heated to an unpermissible degree.

Switchgear of the new design is considerably cheaper than that previously used. As far as Stornorrfor is con-

cerned, it can be reckoned that the cost of busbars and insulators, including the erection, has been reduced by about 35 per cent as compared with the older design. However, it should be noted that, for practical reasons, it would have been impossible to have built switchgear of the older design at Stornorrfor which would have corresponded directly to the design actually used. Therefore, the cost comparison is not completely realistic.

Safety earthing devices

The gear for the safety earthing of the 18 kV switchgear has been designed in the shape of a heavy copper bar of such a length that it can short-circuit the phases. The bar is permanently connected to the earth-line network via an ordinary flexible earth line. When the earthing device is not used, the bar is suspended in the neighbourhood of the busbars. There are wing nuts on the phase conductors with the aid of which the bar can be fastened (Fig. 6). The bar is so robustly designed that it will withstand possible short circuits while, on the other hand, the earth line does not need to be designed for the short-circuit current. The short-circuiting bar is painted in black and yellow strips so that it is possible to see at a glance whether the earthing is applied or not. Because of the fixed safety earthing devices it is not necessary to carry heavy earthing gear through the switchgear installations. It is, in addition, possible to arrange interlocking so that the voltage cannot be impressed until the earthing device has been removed.

Switchgear control equipment

It would scarcely have been technically possible and certainly not economic to install three-pole circuit-breakers with full breaking capacity in view of the conditions

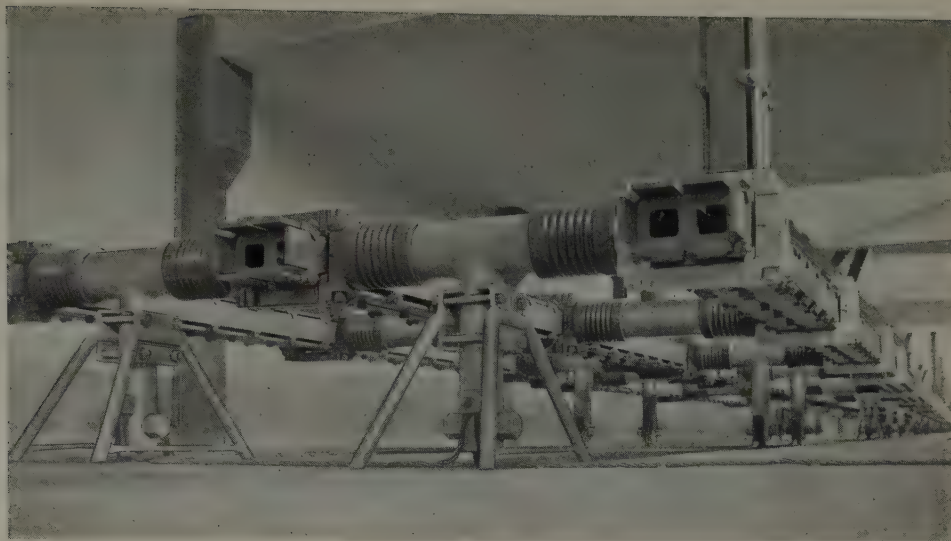
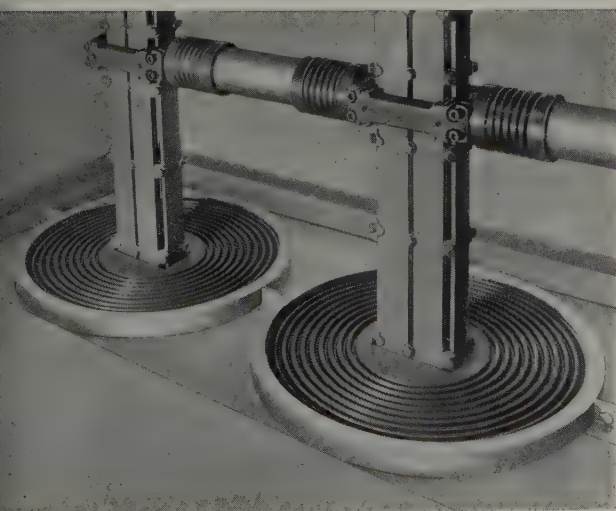


Fig. 4. The 18 kV busbars.
(54895)

prevailing in the 18 kV switchgear, with short-circuit powers up to 5,000 MVA. Therefore, only the two-pole circuit-breakers for the 18 kV windings of the 400 kV transformers, where a breaking current of 100 kA is adequate, have full breaking capacity. For the three-pole circuit-breakers a breaking capacity of 2,000 MVA has been accepted (breaking current about 65 kA) and they are protected against overloading by the fact that tripping of the three-pole circuit-breaker in question is blocked if the short-circuit current exceeds the permitted breaking current, until the 400 kV transformer has been disconnected from the 18 kV busbar in question by tripping of the two-pole circuit-breakers. However, the three-pole circuit-breakers will withstand being closed against the short circuit, the calculated maximum peak value of the surge current then being about 320 kA. All the 18 kV circuit-breakers are of air-blast type.

Fig. 5. Floor bushing for 18 kV with Araldite plate. (54893)



A special feature is that it has been possible to simplify the connection of the auxiliary transformers. The above-mentioned condition that a brief disconnection of a certain part of the production can be tolerated in the case of a fault in an auxiliary transformer has made it possible to connect these to the 18 kV system without any breaking devices, but with the aid of ordinary isolators. To install circuit-breakers here would have meant an unreasonably high cost for the switchgear cubicles of the auxiliary transformers in relation to the cost of the transformers themselves, particularly as the highest short-circuit powers occur at these very transformers. Even if it were possible, by reducing the breaking current with the aid of series reactors, to use smaller circuit-breakers, the total cost of the reactors and the circuit-breakers would have been considerable.

In the event of a fault in an auxiliary transformer, all the circuit-breakers in the 18 kV system affected are tripped. In order to avoid interruptions of this kind as far as possible, the auxiliary transformers have been designed one insulation class higher than the normal. The isolators for the auxiliary transformers have motor operating gear and can interrupt the no-load current. Operation can only be carried out from the control-room, thus eliminating the risk of injury to personnel in the event of faulty operation.

The 18 kV lightning arresters have been arranged in a way which differs from previous practice when three arresters were connected in directly between the phases. Now use is made of four arresters, three in star connection each connected to its own phase and the fourth between the neutral thus obtained and earth. The four arresters are mechanically combined to form one unit. The appearance of the device can be seen in Fig. 7 which, however, shows the two-pole design. A detailed

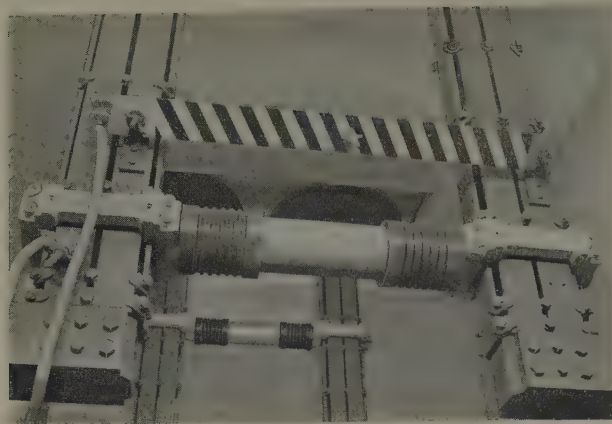


Fig. 6. Safety earthing device in the 18 kV switchgear. (54894)

account of this type of lightning-arrester protection and its properties has previously been published in Asea Journal [5].

Siting within the station

Fig. 8 shows how the 18 kV switchgear is situated in the power-station; see also the article by von Geijer [3, Figs. 3 and 4]. The switchgear is situated in the transformer hall behind the transformer as seen from the transport passage and is thus placed between the generators and the transformers. This has reduced the length of the busbars to the transformers and also to the generators. The busbars for the latter run through separate tunnels in the rock, which is advantageous with reference to accessibility during inspection and when overhauling the busbars. The two 18 kV busbars are beneath the level of the transport passage and the major part of the 18 kV switchgear control equipment is therefore at the same level as the transformers.

THE 400 kV SWITCHGEAR

Because of the circumstances mentioned in the introduction, Stornorrfor has only been provided with one 400 kV three-pole circuit-breaker. This, in its turn, has made possible the use of a special simplified design for the 400 kV switchgear. In each phase, the breaker poles and the appropriate three single-pole isolators are set up around a steel tower. Therefore, the need for steelwork is limited to three towers and the equipment stand, while there are no cross-arms. The appearance of the arrangement can be seen in Fig. 9. Space has been reserved for more conventional switchgear if, in the future, contrary to expectations, a new 400 kV line should be set up. The circuit-breaker is of air-blast type with a breaking capacity of 13,000 MVA and a rated current of 1,500 A.

As has been mentioned above, the circuit-breaker must be by-passed when it is to be inspected or if a break-

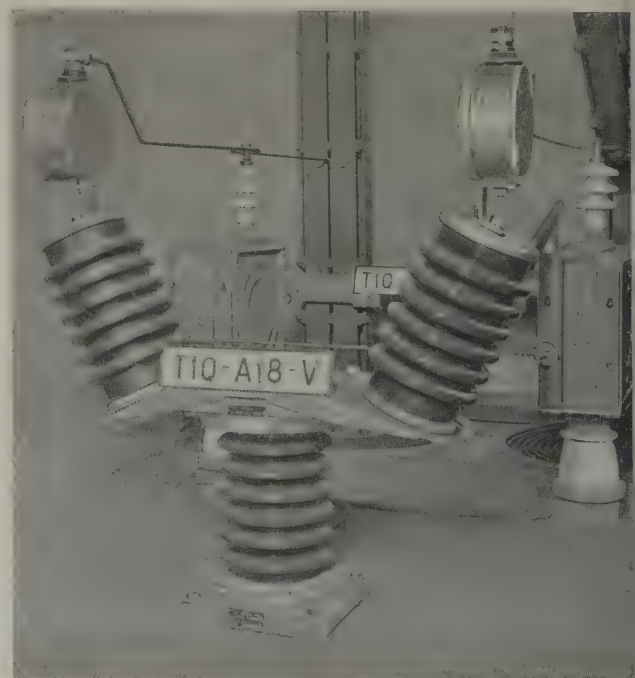
down should occur. If, on such occasions, a fault should occur which would normally have caused a tripping impulse to be sent to the 400 kV circuit-breaker, this impulse is sent instead to the line breaker at the farther end of the 400 kV line, that is to say, in Harrsele. The transmission of the impulse goes via carrier frequency on the 400 kV line.

The link between the terminals of the 400 kV transformer units and the outdoor switchgear consists of four single-phase cables. In conjunction with the upper cable end boxes of the cable there is isolator switchgear for connecting up the spare unit. At the upper end of each cable there are cable current transformers thus obviating the use of expensive free-standing 400 kV current-transformers. The lower cable end box is directly built on to the transformer unit. This arrangement has previously been described in an article by Sollergren in Asea Journal [4, p. 52, Fig. 7].

The cables run in a shaft and are placed on insulated wooden blocks. The lead sheathing is directly earthed in one place only, thus avoiding induction currents along its length which would give rise to extra losses and an unnecessary rise in the temperature.

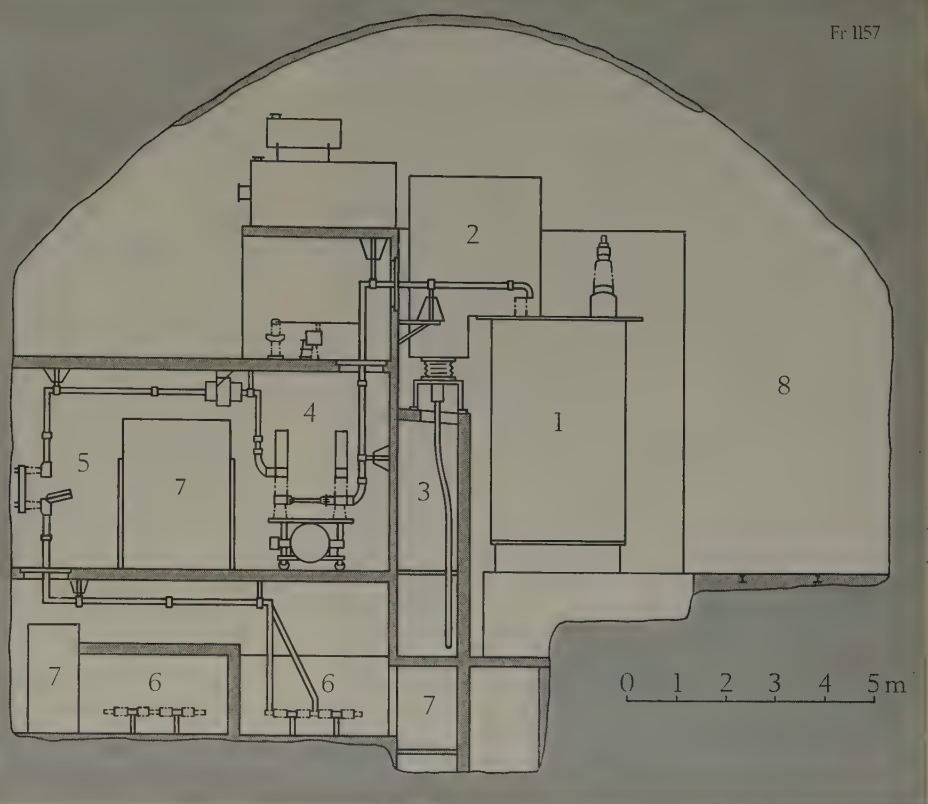
The 400 kV cables are designed for a service voltage of $500/\sqrt{3}$ kV and are of Insulation Class 1600. The cross-sectional area is 405 mm² (0.63 sq.in.) and the cables can be continuously loaded with a current of 1,600 A. They are oil-filled and fitted with a circulating system for cooling the oil in an external water-cooled radiator. This additional cooling is switched in automatically as the load increases.

Fig. 7. 18 kV lightning arrester. (54892)



- 1 400 kV transformer
- 2 Lower 400 kV cable end box
- 3 400 kV cable
- 4 18 kV circuit-breaker
- 5 18 kV isolator
- 6 18 kV busbars
- 7 Inspection passages
- 8 Transport passage

Fig. 8. Vertical section through a 400 kV transformer compartment and an 18 kV switchgear bay.



THE 40 kV SWITCHGEAR

The steelwork for the 40 kV switchgear is really intended for 130 kV outdoor switchgear. Each bay houses two 40 kV units. The object of this is to simplify a future transition to 130 kV on certain of the outgoing lines which now have a voltage of 40 kV. This change is most likely in the case of Umeå town, the largest consumer. However, in this way, the switchgear has taken on a somewhat unusual appearance in which the abnormally high towers and the long cross-arms seem out of place in view of the present service voltage.

The circuit-breakers in the 40 kV switchgear are of oil-minimum type with a breaking capacity of 1,500 MVA. The link between the 40 kV transformers and the outdoor switchgear consists of two three-phase cables running in a shaft like the 400 kV cables.

SWITCHGEAR AND CABLES FOR AUXILIARY POWER

For the auxiliary power requirements, the power-station has a network at a voltage of 3×380 V having a neutral with a highly resistive earth, as well as a network at a voltage of 380/220 V with a directly earthed neutral. The latter system is mainly intended for lighting and is fed from the first system mentioned via two small transformers with the ratio 1:1. Because of the large area covered by the power-station and its installation it has

been found advantageous to make use of a 10 kV auxiliary system too for feeding the more remote loads such as the spillways, intakes and outdoor switchgear. This system is fed from the 40 kV system via a 4 MVA transformer (LT8 in Fig. 1) with the ratio of 44/11/0.4 kV and has a number of step-down transformers from 10 kV to 380/220 V. The 3×380 V power-station network is fed from the 18 kV system via two 2 MVA transformers (LT1 and LT2 in Fig. 1) with the ratio of 18/11/0.4 kV, which are also connected via their third winding to the 10 kV system. In this way, the power-station can receive an emergency supply from the 40 kV system via the 10 kV system and the 18 kV auxiliary transformers, and, in addition, feeding of the 10 kV system from the 18 kV system is also made possible. Both the 10 kV auxiliary switchgear and the main distribution board for the 3×380 V systems are designed as ordinary sheet-steel-clad switchgear.

The low-voltage cables of the auxiliary-power installation are designed in accordance with the new Swedish Standard SEN R 24 14 01 and are thus plastic-insulated, plastic-sheathed and screened cables (type FKKJ). The three plastic-insulated phase conductors have normal cable design while the neutral conductor is designed as a screen of flat copper wire around the phase conductors and is placed between two plastic sheaths. The plastic cables used are, from several points of view, more advantageous than conventional lead-sheathed cable, not

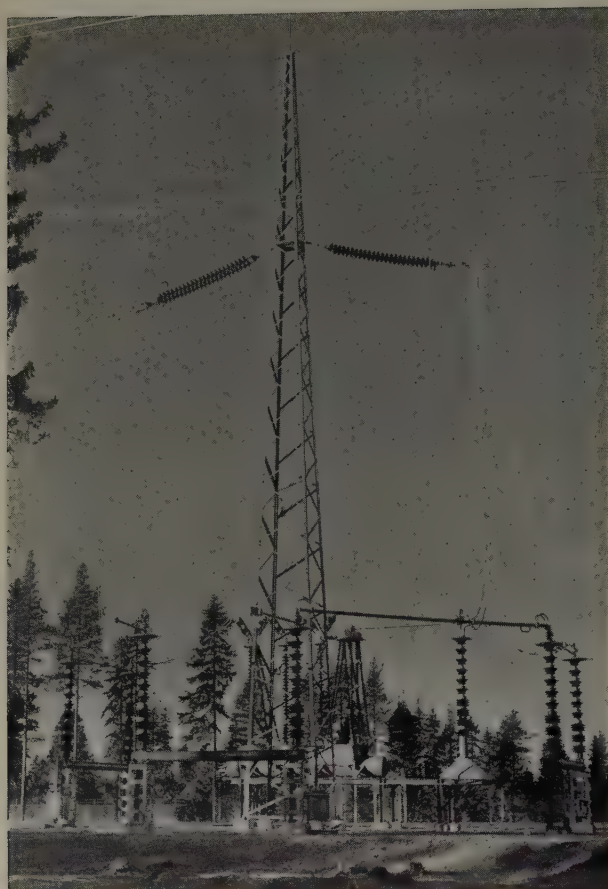


Fig. 9. Single-pole circuit-breaker for 400 kV with appropriate isolator. The open isolator in the foreground is the by-pass isolator. (54891)

least because of the lower cost of installation. As compared with lead-rubber cables, the cost of cable including its placing on cable ladders was almost 40 per cent lower, worked out on the basis of cables with a cross-sectional area of conductor of the order of size of 50 mm² (0.08 sq.in.). In the case of greater cross-sectional areas, the plastic earth cable should, instead, be compared with lead-paper cable and the corresponding reduction in cost would then be about 10 per cent for areas of the order of size of 240 mm² (0.37 sq.in.). The saving in absolute figures at present-day prices is about the same in both cases and amounts to almost 10 Sw.kr per m. When comparing with lead-paper cable, there is the additional fact that the plastic earth cable makes possible a considerable simplification as far as the cable end boxes are concerned, thus making the cost of these, including erection work, about 30 per cent lower than in the case of lead-paper cable. It should, however, be noted that plastic earth cable has a permissible short-time current which is about 35 per cent lower than for a lead-paper cable with the same cross-sectional area, for which reason, in certain cases, a larger cross-sectional area of plastic earth cable may be required than would be the case for lead-paper cable.

SUMMARY

The most characteristic features as far as the switchgear at Stornorrfor is concerned are the new design of the 18 kV switchgear and the simplified 400 kV switchgear. The use of plastic-insulated low-voltage cable without a lead sheath is also of interest.

The newly designed generator switchgear has, as far as it is possible to judge at the present moment, been most successful, not least because the design has made possible very simple and easy erection. The advantages from the point of view of costs have already been dealt with above. Araldite insulators have also been used in, for example, the steam power-station at Stenungsund, although there, for various reasons, it was decided to place the greater part of the busbars in a sheet-steel tube. Further, the material of which the busbars were made there is aluminium. Exactly the same design as at Stornorrfor has been adopted at several hydro-electric power-stations built later.

The design of the 400 kV switchgear in use at Stornorrfor should probably be regarded as unique and not to be repeated in that it was made possible by the unusual relation of the power-station to the network. For a later hydro-electric power-station with very similar, but not quite identical conditions, a new type of switchgear has been designed, in which the stand-by 400 kV transformer too is provided with a single-pole circuit-breaker on the 400 kV side. This type is, in addition, so designed that future extension to make it into ordinary switchgear with several outgoing lines is somewhat simpler.

The plastic-insulated low-voltage cable with the copper-wire screen, but without a lead sheath, has proved most satisfactory during erection and there is no reason to suppose that it will prove any less satisfactory in service. It seems probable that the next stage in development will be the use of plastic-insulated cable for auxiliary power even in the case of voltages up to 10 kV.

LITERATURE

1. Stornorrfor kraftstation [Stornorrfor Power-station]. Swedish State Power Board, Blue-white Series No. 19 [reprint from Teknisk Tidskrift 87(1957):48].
2. von Geijer, G., Svidén, S., Den elektriska utrustningen i Stornorrfor kraftstation [The electrical equipment in Stornorrfor Power-station]. ERA 32(1959):1, pp. 2-7.
3. von Geijer, G., Stornorrfor Power-station. Asea Journal 33(1960):1-2, pp. 3-8.
4. Sollergren, B., The Stornorrfor transformers. Asea Journal 33(1960):4-5, pp. 47-55.
5. Greve, A. W., Over-voltage protection for generators and other equipment in non-vulnerable positions. Asea Journal 29(1956):11-12, pp. 148-152.

NEW CONTACTORS AND CONTACTOR-OPERATED 10 A DIRECT-ON-LINE STARTERS

Johan Eric Carlsson, Apparatus Design Department, Västerås

U.D.C. 621.316.53
Asea Reg. 5354

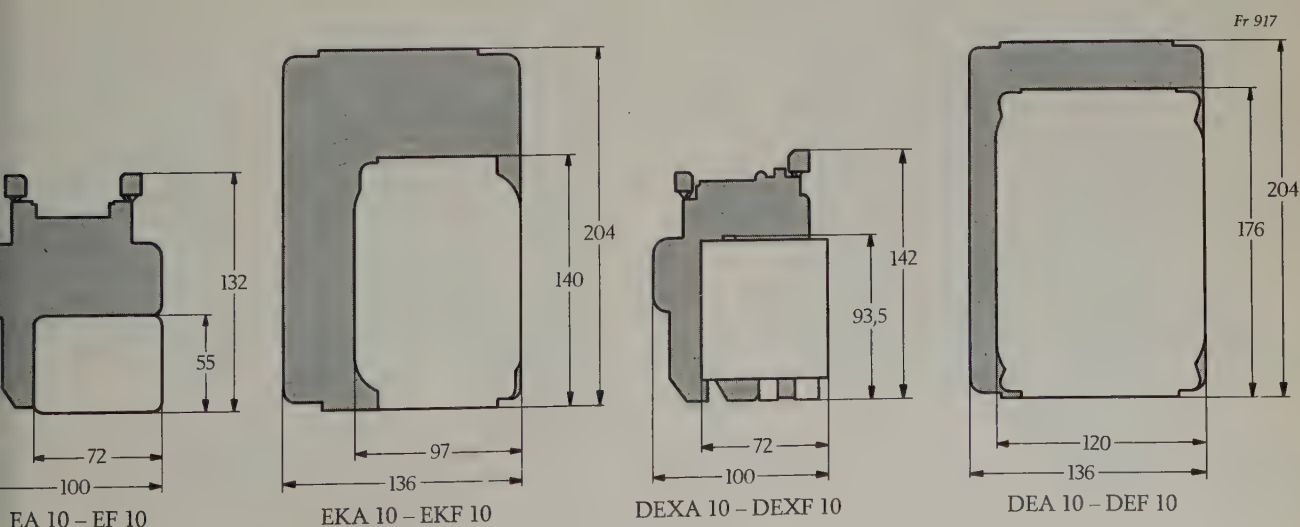
The new contactor EF 10 and the new contactor-operated direct-on-line starter DEF 10 for a rated current of 10 A are described, as are their variants and different combinations. Their small dimensions, their modern appearance and their long life are stressed.

Contactor-operated direct-on-line starter DEA 10 [see Asea Journal 16(1939):11, pp. 157-159] has hitherto been the smallest direct-on-line starter for remote operation manufactured by Asea. The basic component, the EA 10 contactor, is incorporated in many starter equipments and the number of units supplied since 1939 approaches a million. This fact reflects the satisfaction of our customers and direct-on-line starter DEA 10 will therefore continue to be manufactured in the future. However, to meet the demands for a less bulky apparatus and for easy changing of the component parts, 10 A equipment is now being manufactured, mainly in accordance with the principles previously described in Asea Journal 32(1959):3, pp. 34-38 for larger contactors.

CONTACTOR EF 10

The new contactor has the type designation EF 10 and the contactor-operated direct-on-line starter DE(X)F 10, see Fig. 2. The space required as seen from the front as compared with type EA and DE(X)A 10 can be seen

Fig. 1. Comparison between the space requirements, as seen from the front, for types EA, DE(X)A (shaded areas) and EF, DE(X)F 10 (unshaded areas). (Fr 917)



from Fig. 1, and, in the case of the contactor, amounts to only 30 per cent of the space required for the older equipment. It is a simple matter to change the coil and only two screws need to be removed, as will be seen from Fig. 3. The moving contacts can be changed quite simply by pulling out or pushing in the contact beneath the spring holders in the contact bridge with the aid of a small pair of flat-nosed pliers. The fixed contacts can be changed after the connecting screws have been slackened.

Contactors EF 10 consists, as shown in Fig. 3, of two main parts, a contact housing consisting of a non-tracking plastic material, and a bakelite lower part with magnet core and coil. All the contacts have two breaks with contact surfaces of rolled silver. The main and auxiliary contacts are identical. Type EF 10 has four making, and two breaking, contacts. Thus, it can be used as a reconnecting contactor, for example as an automatic emergency lighting switch for a maximum rating of 220 V, a.c. or d.c. For the automatic operation of a motor, the above-mentioned number of contacts may sometimes be too small. If this is the case, type EF 10-2 should be selected, as this has a different contact housing containing three main contacts and two making, and two breaking, auxiliary contacts. On special request, the EF 10 and EF 10-2 can, in addition, be fitted with an air-damped, time-lag auxiliary contact. Air circulates within the device which is therefore not affected by pollution of the ambient air. Tests have shown that it also functions at a temperature of -40°C .

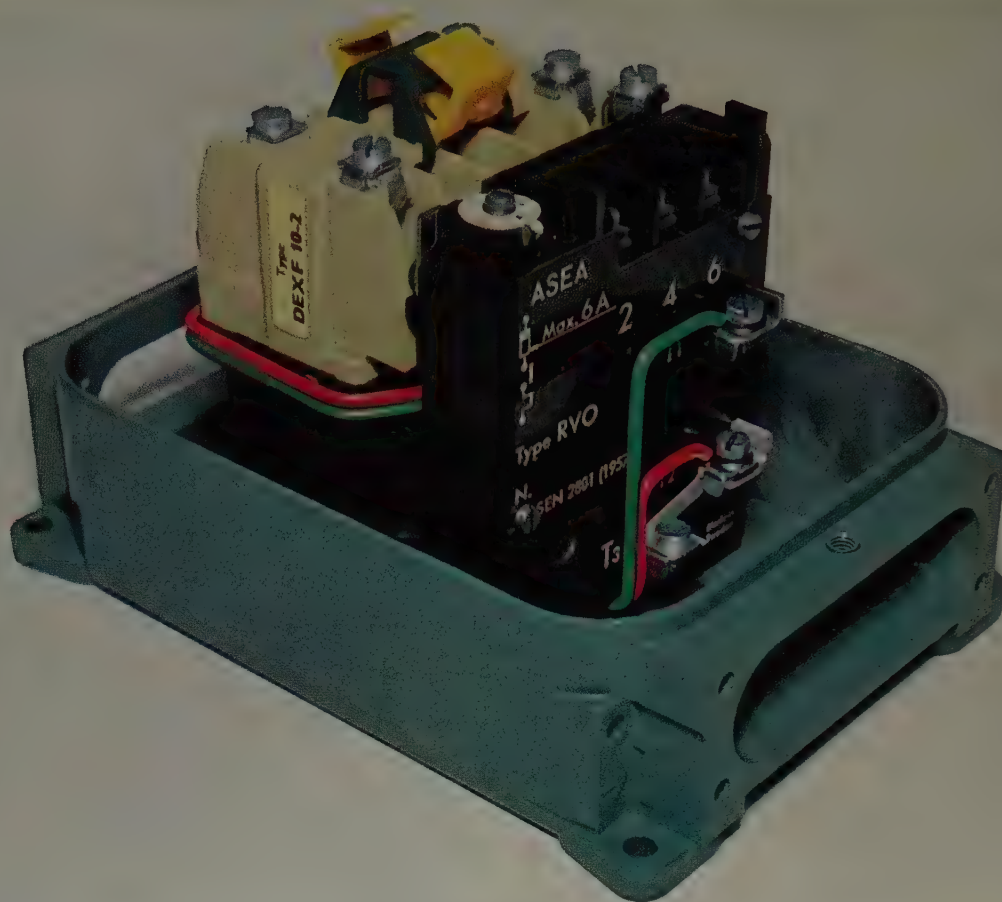


Fig. 2. The new contactor-operated direct-on-line starter DEF 10-2. (F 473)

The contactor has been put through a comprehensive type test and will fulfil the demands for breaking and making capacity set up in Swedish Standard SEN 28 01. Durability tests are now going on and a mechanical life of over ten million operations has been attained. The contactor has the following electrical data:

Type EF 10
 Rated current 10 A
 Rated voltage 500 V
 Intended for three-phase motors with maximum rating 4.2 kW
 Contact life at $I_{st}/I_n=5$ and maximum motor output 3×10^6 operations
 Power consumption of the coil
 Closing 50 VA
 Service 8 VA; 3 W

CONTACTOR-OPERATED DIRECT-ON-LINE STARTER DEF 10

The three-pole thermal relay of the type designation RVO (Fig. 4) incorporated in the starter is a readily changeable unit which is screwed to the terminal clamps of the contactor. The enclosed design protects the relay

against accidental external interference which could otherwise affect the accurate adjustment which is made to the relay before it is supplied. The relay is compensated against variations in the ambient temperature. In order to achieve a high degree of reliability in service notwithstanding its small dimensions, an attempt has been made to make its design as simple as possible. As a result of this, the relay is only available with either hand resetting or automatic resetting. In the former case, the bimetallic strip quite simply releases the contact spring which is locked by the setting device, and in the latter case this locking device is replaced by a nylon roller which runs along the curved part of the contact spring (Fig. 4).

From the point of view of safety, manual resetting should normally be used since this prevents accidental starting after a tripping operation if, for any reason, the operating circuit should be closed. For example, in the case of thermostat operation, manual resetting should always be used in order to prevent the danger of "pumping" when a fault arises.

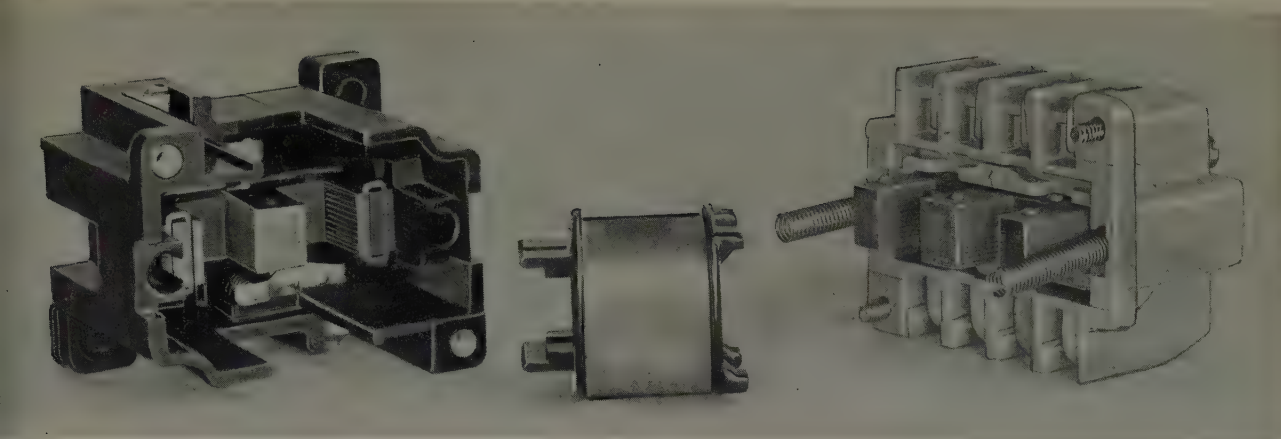


Fig. 3. Contactor EF 10 dismantled for coil changing. (53474)

The resetting button also serves as the stop button, and thus starting cannot be carried out when the resetting button is locked. The number of contacts has been reduced to a minimum in that the stop contact and the relay contact have been combined.

The enclosed direct-on-line starter with a die-cast light-alloy casing can be supplied in the following four variants:

DEF 10-1 with three main contacts and one hold-in contact, but without other auxiliary contacts. The contact has a mechanical indicator with a yellow field for "Closed" and a green one for "Open" which can be seen through a window in the cover. The relay is provided with manual resetting and built-in push-buttons for starting and stopping (Fig. 5), which has been the standard Asea design for many years.

DEF 10-2 with three main contacts, one hold-in contact, one making, and two breaking, auxiliary contacts and with the same relay as in type DEF 10-1.

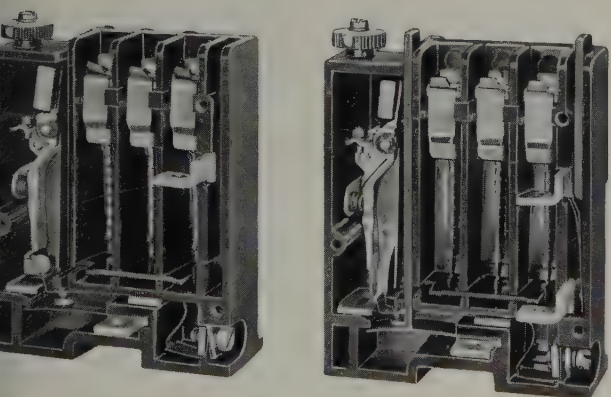


Fig. 4. Relays type RVO (to the right) and RVO-1 (to the left). The covers are removed to show the simple and robust design. (53473)

DEF 10-21 with the same contactor as in type DEF-1, but the relay is provided with automatic resetting and there are no pushbuttons (Fig. 6).

DEF 10-22 with the same contactor as in DEF 10-2 and the same relay as in DEF 10-21.

Naturally, these direct-on-line starters are also supplied without housings for building into various types of equipment.

STANDARDISED COMBINATIONS

Contactor EF 10 and thermal relay RVO have also been combined in various kinds of starting equipment of enclosed, or open, design. Direct-on-line reversing starters, direct-on-line pole changing starters for two-speed motors with one or two windings and Y/D switches can be housed in the casing which is used for direct-on-line starter DEF 25. These new starters have thus been given a practical design and an attractive appearance.



Fig. 5. Contactor-operated direct-on-line starter type DEF 10-1 or DEF 10-2. (52530)



Fig. 6. Contactor-operated direct-on-line starter type DEF 10-21 or DEF 10-22. (52656)

The contactor with built-on time-lag contact has also made possible a practical solution to the question of delayed under-voltage tripping of contactors. Normally, the coil of the contactor-operated direct-on-line starter is fed from the same current source as the motor. When the supply voltage fails, the contactor drops open and remains disconnected when the voltage returns if it is operated by means of pushbuttons. If the high-voltage supply network is provided with rapid auto-reclosing devices the direct-on-line starter should also, naturally, be reclosed if service is of such a kind that an interruption would cause serious difficulties.

Time-lag under-voltage tripping can be arranged with separate feeding of the contactor coils from, for example,

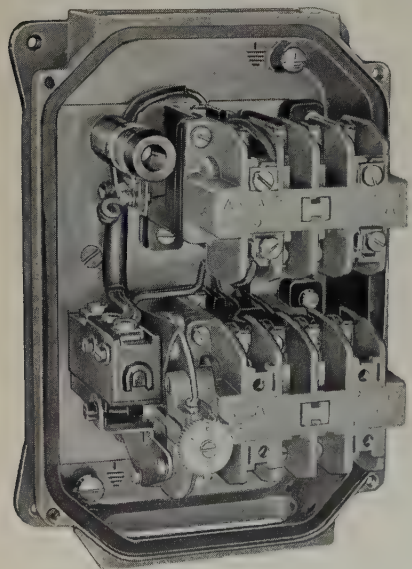
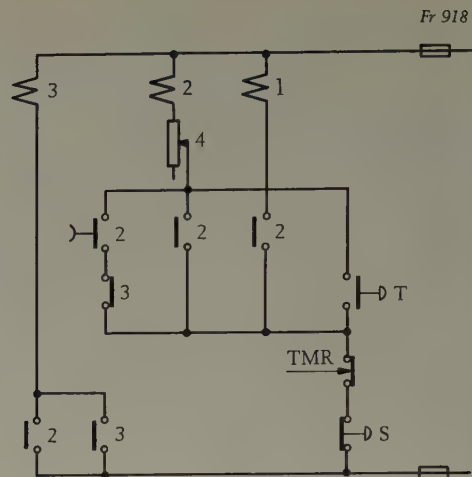


Fig. 7. Equipment for time-lag under-voltage tripping. (53431)



1. Direct-on-line starter
 2. Contactor with built-on time-lag contact device
 3. Contactor
 4. Setting resistor for the closing value
- TMR. Thermal over-load relay
T. Starting button
S. Stop button

Fig. 8. Circuit diagram for direct-on-line starters DEF 25, 40, 60 and 100 with time-lag under-voltage tripping by means of the equipment shown in Fig. 7. (Fr 918)

a flywheel converter which, however, requires a special supply network for the operating circuit. It is simplest to provide the hold-in contact of the contactor with a time delay, but then, when opening, the stop button must be kept pressed in during the whole time-lag period. This disadvantage is obviated if the time-lag hold-in contact is only put into operation when the line voltage fails. Thus, the method means reclosing of the direct-on-line starter if the voltage returns within the set time. A simple additional device with this function is shown in Fig. 7, with a circuit diagram as shown in Fig. 8. It consists of two EF 10 contactors, of which the one is provided with the previously described time-lag contact. None of the auxiliary contacts of the main contactor (1) is used and all normal operating devices can be connected to it. The equipment requires little space and can be supplied enclosed in the same housing as for contactor EKF 25. It is particularly suitable for supplementing direct-on-line starters already installed.

As a further example of various designs, mention can be made of direct-on-line starters for circulation, and twin pumps with contacts for signalling both in the case of under-voltage, and over-load tripping. There is a wide range of use for these readily adaptable pieces of equipment.

DR UNO OLSSON'S WORK ON NON-CIRCULAR GEARS CONCLUDED

In 1953, a treatise written by the then Mr Uno Olsson and entitled "Non-circular cylindrical gears" was published in Acta Polytechnica. This outstanding work was reviewed in Asea Journal 27(1954):11-12, p. 188. The work was submitted as a Ph.D. thesis in April 1957.

This work said practically all that could be said about non-cylindrical gears which form, in many cases, extremely valuable machine components. The idea of such gear-wheels is in itself old, but, because of the lack of rational methods of calculation and manufacture, they had, previously, been used to a very slight extent.

However, Dr Olsson did not rest on his laurels. In 1959, he put forward a similar work entitled "Non-circular bevel gears". This work was characterised by the same perspicuity and thoroughness as the previous one. Even though the bevel gears do not have the same significance

as the cylindrical ones, it is, nevertheless, extremely valuable that their theory has been put forward in this way and that their use in practical designs has been made possible.

Fig. 1. Dr Olsson with some of his non-circular cylindrical gears. (Z 11104)

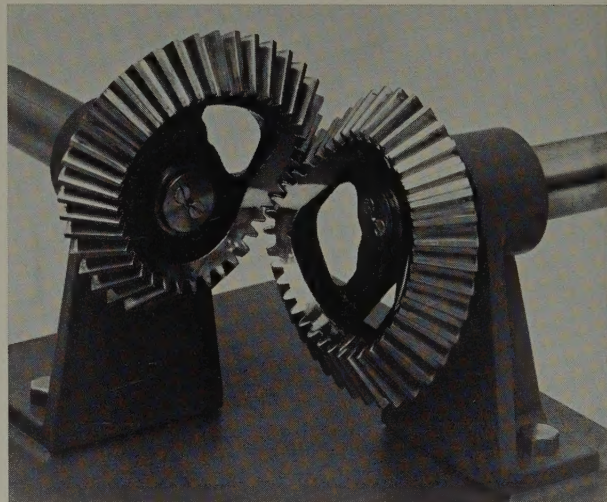
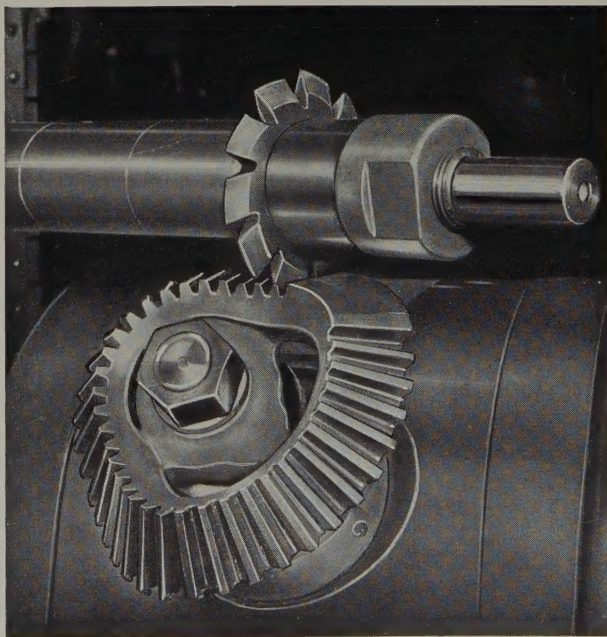
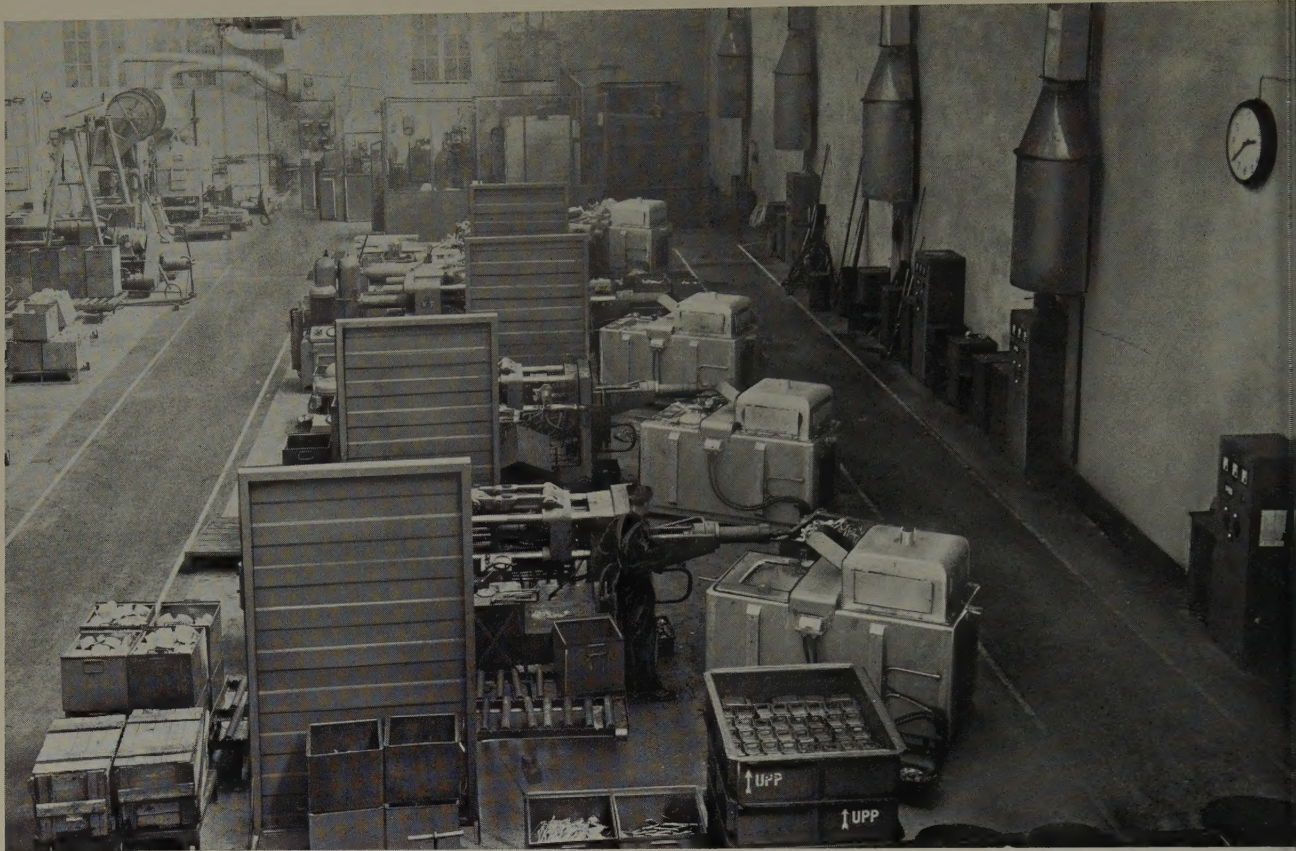


Fig. 2. An example of non-circular bevel gears. (54666)

Fig. 3. Cutting a gear-wheel for one of the components of the bevel gears in Fig. 2. (Z 11105)





(55118)

NEWS IN BRIEF

TWO-CHAMBER INDUCTION FURNACES WITH MELTING DUCTS IN THE ASEA FOUNDRIES

Six low-frequency, two-chamber furnaces, five of which are for silicon-alloyed aluminium and one for brass, have been installed in the Asea light-alloy foundries

in Västerås. The furnaces, which serve the die-casting machines, have a rating of 40 kW. They have been in uninterrupted service since the beginning of 1960. Since the furnaces serve both as melting furnaces and holding furnaces, they have replaced the previous melting furnaces of tilting type, each of which

had its own small holding furnace. The furnaces consume only a small quantity of energy and are very economical in service.

The illustration shows four of the six furnaces installed. A further six furnaces are to be added in the near future.

Asea Reg. 6642

SEPARATE THERMAL RELAYS

The thermal relays in direct-on-line star-

ters (type DEF) are also supplied as separate thermal relays for use in contactor-type switchgear or other electrical equipment for motors. The following types are available:

For a maximum rated current of 25 A:

Type RVXL, open design

Type RVXL-F with a front-plate in accordance with Swedish Standard SEN 28 07 01

Type RVKL, splash-proof design (see Fig. 1)

All the above-mentioned types have easily changeable plug-in type releases with 13 different scales graduated from 0.2 to 25 A. The relays have one making, and one breaking, contact and a signal lamp. They are reset by means of a pushbutton after tripping, but automatic resetting can also be provided if specially requested.

The following types are available for higher rated currents:

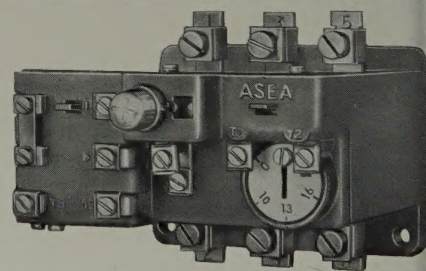


Fig. 2. Thermal relay type RVXM 40 for a rated current of 40 A, open design. (53729)

Type RVXM 40 (see Fig. 2) and RVXM 100, which are of open design and are for rated currents of 40 and 100 A respectively. There is, in addition, type RVXM 40 F with a front-plate and RVKM 100, which is of splash-proof design. These relays have one making and one breaking, contact and can be switched over from hand resetting to automatic resetting. A signal lamp can also be supplied if desired. Asea Reg. 562

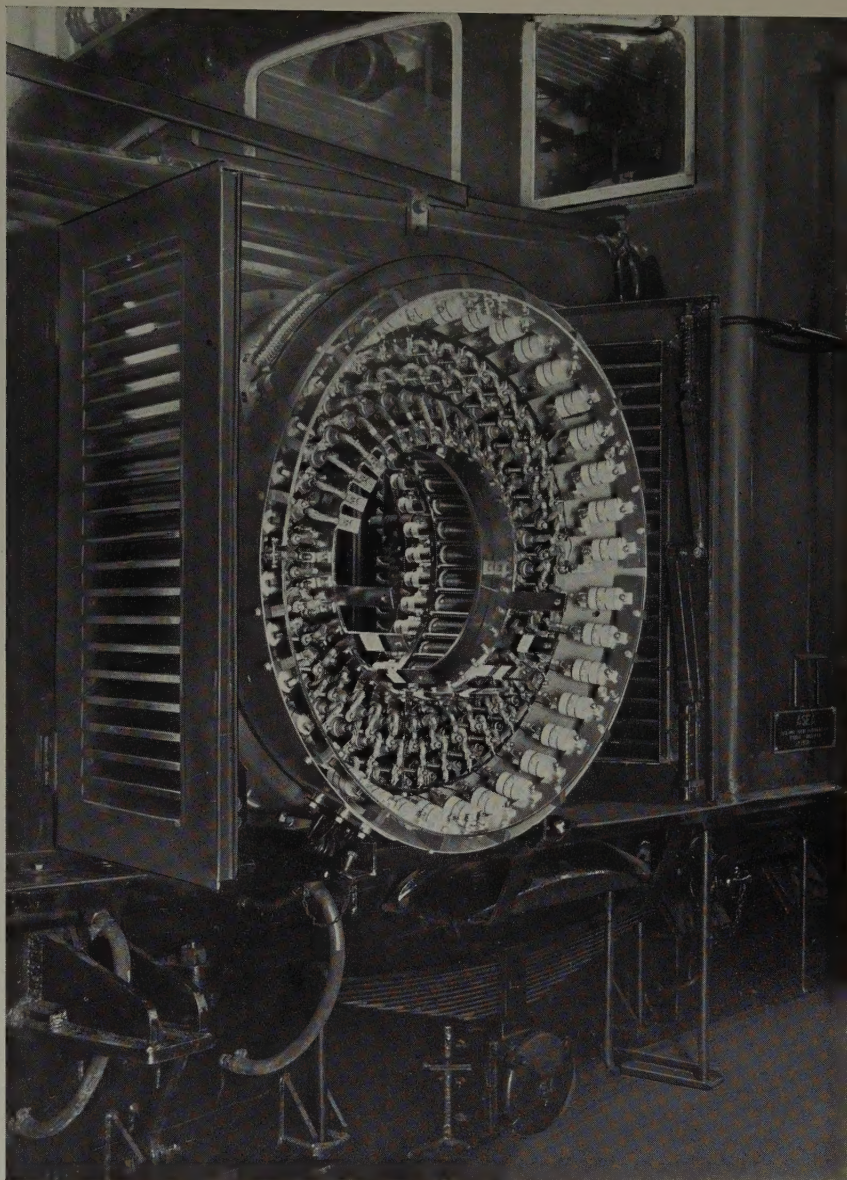


Fig. 1. Thermal relay type RVKL for a rated current of 25 A, in a splash-proof casing. (53284)

EXPERIMENTAL LOCOMOTIVE EQUIPPED WITH SILICON RECTIFIER

In order to test silicon rectifiers to ascertain the extent to which they can be used for traction service on railways, Asea have converted an old locomotive of type Öc into a rectifier locomotive. The locomotive, which was placed at the disposal of Asea by the Swedish State Railways, has a rated motor output of 25 h.p. and is geared for a maximum speed of 75 km per hour (47 m.p.h.).

The rectifier is air-cooled and the rectifier cells with their cooling devices are mounted concentrically around a fan wheel of centrifugal type. The rectifier assembly is fitted with wheels and can be drawn out along special rails through a door in the side of the locomotive. The illustration shows the rectifier assembly half-way withdrawn. Asea Reg. 6134



(54653)

NEW RELAY CASES OF SIZE H2

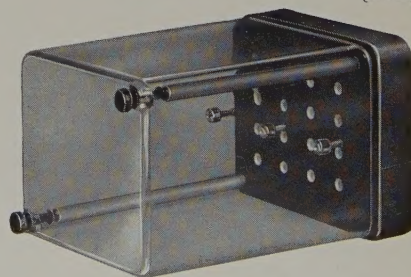
Modernisation and standardisation of relay cases has been proceeding for several years, see the article in the Asea Journal 29(1956):4, pp. 47-49 (also published as Pamphlet 7503 E). A new type, size H2, has now been added to the series.

The new case is to be used for certain small relays for fixed mounting, for example, types RIC and RME, and as a two-seat case type RHGA 2 (see the

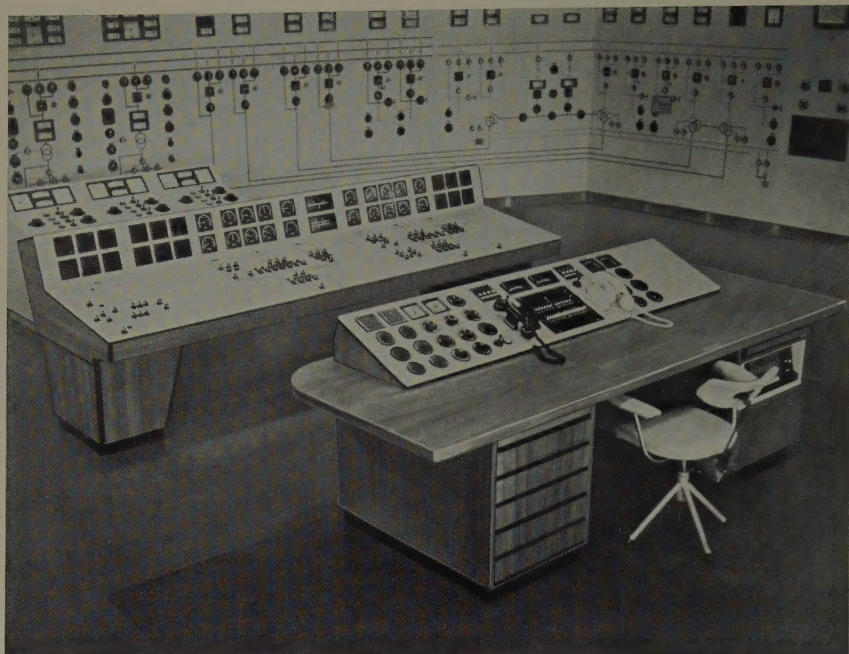
illustration and Pamphlet 7057 Eb) for plug-in type relays. The cover, which is made of transparent plastic, is removable and great care has gone into the designing of the fastenings so that the cover can easily be removed and replaced.

The case is fixed on a panel and connected up from the rear. However, with the aid of extra equipment, it is possible to connect up the case from the front or to mount it flush with the panel.

Asea Reg. 5283



(55353)



(54276)

REGULATING EQUIPMENT FOR THE POWER-EXCHANGE SYSTEM BETWEEN SWEDEN AND FINLAND

Amongst other items for the transmission line linking the Swedish and Finnish grids, which was taken into service in 1959, Asea have supplied equipment for the automatic regulation of the power exchanged. The equipment is unique in so far as all the elements of the regulating equipment are entirely continuous in their action. All the metering and control signals consist of electrical currents or voltages to the hydraulic power amplification which is required for operating the turbine gates.

In 1959, the installed generator output was about 8,000 MW in Sweden and about 2,000 MW in Finland, while the transmission capacity of the line linking the two grids is 150 MW. The system bias (without regulators) is 200 MW/c/s in Sweden and 40 MW/c/s in Finland. Because of this, the regulation of the power exchanged is carried out in the Finnish grid, while the common grid frequency is controlled by the Swedish power-stations.

The regulation of the power exchange is carried out in the three Finnish power-stations Pyhäkoski, Montta and Pälli in the Ule River, where the possibilities of regulation are good. The power on the linking transmission line is measured at Petäjäskoski and transmitted to Pyhäkoski, from which point the other two stations are also regulated.

The illustration shows the control room at Pyhäkoski Power-station. Next to the control panel, the desk for the electric turbine regulators can be seen, and, in the foreground, the writing desk with the equipment for the remote regulation of the Montta and Pälli power-stations and for the regulation of the power exchange or the total output of all the stations.

Asea Reg. 572

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All correspondence should be addressed to the Editor, Publicity Department, Asea, Västerås, Sweden.

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